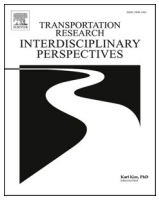
Transportation Research Interdisciplinary Perspectives 23 (2024) 101026

Contents lists available at ScienceDirect

Transportation Research Interdisciplinary Perspectives

journal homepage: www.sciencedirect.com/journal/transportation-research-interdisciplinary-perspectives



Socio-environmental factors associated with active school travel in children at ages 6 and 8 years

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ARTICLE INFO

Keywords:
Active transport
Path analysis
Social environment
Child health
Socio-demographic factors

ABSTRACT

Active school travel (AST) confers considerable health and environmental benefits. While evidence on AST associates for older children, and in relation to the physical built environment, has grown significantly over time, less is known regarding AST associates in younger children and socio-environmental associates of AST in this age group. In this research, we seek to determine the relationships between a range of factors across the ecological spectrum and children's AST at 6 years and at 8 years of age, controlling for maternal education and number of times moved since 4 years. Structural equation modelling was used to identify factors associated with AST at 6 years. Due to the poor overall fit for the 8 year SEM model, a path model was instead performed to explore the direct relationships between AST and other observed variables. At both 6 and 8 years, importance of living close to schools had a significant and positive relationship with AST (standardised estimates = 0.31 and 0.19 respectively, both $p < 0.001$), and a significant negative relationship with AST was found for perceived distance to schools (estimates = -0.46 and −0.47 respectively, both $p < 0.001$). At 8 years, negative associations with AST were detected for parent/caregiver involvement with school (-0.071, $p = 0.099$) and children being of Pacific ethnicity (-0.100, $p = 0.030$). Distance remains the overriding factor associated with AST in young children – efforts to ensure children have easy access to, and are supported to attend, schools in close proximity to home are warranted.

Introduction

Active school travel (AST; getting to or from school using active modes) confers health and environmental benefits, predominantly through increased physical activity and reduced vehicle-related air and noise pollution (Lee et al., 2008, Faulkner et al., 2009, Saunders et al., 2013, Schoeppe et al., 2013, Larouche et al., 2014). AST levels in Aotearoa New Zealand (NZ) have declined substantially over recent decades and are amongst the lowest worldwide (Aubert et al., 2018b, Aubert et al., 2018a, Smith et al., 2018, Smith et al., 2019b). In Tāmaki Makaurau/Auckland (NZ's largest city) a 2020 survey of 94,679 children and youth showed almost half were travelling to school by car daily (Walker, 2020). Urgent intervention to shift children's school journeys from private car use to active modes in NZ is imperative for improved human and planetary health (Reis et al., 2021, Toner et al., 2021). Given activity behaviours track over time (Telama et al., 2005), intervening early in life holds significant potential for improving both current and future health.

A socio-ecological approach to understanding AST in young children

The landmark environment-behaviour and ecological systems

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https://doi.org/10.1016/j.trip.2024.101026
Received 5 October 2023; Received in revised form 17 January 2024; Accepted 27 January 2024
Available online 6 February 2024

theories posited by Stokols (1977) and Bronfenbrenner (1979) highlighted the links between humans and their environments, recognising that human behaviours cannot be explained solely through individual psychology or intrapersonal factors. Field-specific theoretical developments have drawn significantly from these two theories – perhaps the most pertinent in active living research being the socio-ecological model of Sallis et al. (2006). A range of theoretically-derived frameworks exist for understanding children's AST (McMillan, 2005, Panter et al., 2008, Mitra, 2013, Ikeda et al., 2019) which vary in foci, but all draw from this socio-ecological lens to some extent. Such socio-ecological approaches are useful to understand the multiple layers of influence on AST, including factors across individual, family/household, school, neighbourhood, and wider policy and practice levels (Sallis et al., 2006, Sallis et al., 2008, Ikeda et al., 2018a, Ikeda et al., 2018c, Ikeda et al., 2019, Sanz-Martín et al., 2022). This research utilises a socio-ecological approach to focus our analyses on where clear knowledge gaps exist across the socio-ecological spectrum. Key factors of relevance to this research are introduced briefly below.

Policy and practice

In NZ, transport agencies and local and regional councils play a crucial role in supporting AST through policymaking and provision of safe infrastructure, as well as working directly with schools to support AST programmes (Hawley et al., 2019, Smith et al., 2020, Ikeda et al., 2021). These stakeholders face numerous challenges in promoting AST - for example Mackie et al. (2022) highlight the dominant regime of automobility with the NZ transport system that continues to prioritise, and cater to, private motor vehicles through policy directives and downstream funding allocations and decision-making for practice. In this policy and practice context, providing targeted evidence (e.g., findings for specific age groups and settings) that facilitates strategic prioritisation of activities with limited funds and workforce capacity is paramount.

Physical environments

Unsafe transport environments are key concerns of both parents and children (Ikeda et al., 2018, Aranda-Balboa et al., 2020, Buttazzoni et al., 2023). A substantive international evidence base exists for associations between objectively assessed built environment characteristics and children's AST (Wong et al., 2011, Ikeda et al., 2018, Smith et al., 2020). Links between AST and safe infrastructure for walking and cycling, street connectivity, residential density, and aggregate indicators of walkability have been reported (Wong et al., 2011, Smith et al., 2017, Ikeda et al., 2018c, Rothman et al., 2018). Across this heterogeneous evidence base, distance to school is the variable most consistently significantly associated with AST. Whether this relationship is true specifically for younger children in their earliest school years (who may have other overriding factors that drive parental decision-making) is unclear.

Social and school environments

Schools play an integral role in supporting AST through policies and practices, establishing and maintaining an active school travel culture, and partnering with community organisations for delivery of programmes and infrastructure (Smith et al., 2020). Ensuring safety dominates school decision-making regarding AST (Ikeda et al., 2021) – linking with the physical environment level of the socio-ecological model. While much is known about effective programme delivery and factors for improving safety (Villa-González et al., 2018, Jones et al., 2019), less is understood about the socio-cultural aspects that might support AST (Hawley et al., 2019).

Emerging evidence shows positive associations between AST and parent perceptions of the neighbourhood social environment, as well as their reported importance of social interactions (Ikeda, et al., 2019). Similarly, increased children's independent mobility has been associated with higher levels of parent perceived neighbourhood social connectivity and cohesion (Lin et al., 2017). Reasons for these relationships are unclear, but are likely to be linked to an increased sense of safety in the local environment through direct connections with others, or through a perception that the community is socially connected and therefore safe. There may also be a pragmatic link whereby greater social connections provide practical support for AST, such as taking turns walking each others' children to school, or linking groups of children to get to school together actively.

Work with children in middle school years has also highlighted the value children place on connecting with others during their active school journey (Egli et al., 2018, Donnellan et al., 2020, Egli et al., 2020). For example, a study with over 1100 children aged 9-13y in Tāmaki Makaurau/Auckland asked children what they like about their trip to school – a significant portion of children noted that they enjoyed spending time with their friends, and talking with friends, siblings, and parents (Egli et al., 2020). Similarly, in a study evaluating the impact of a new shared path on AST, children highlighted social connections as a key benefit of AST (Donnellan,Egli et al., 2020).

In this research we focused on contributing to this small evidence base by measuring the social links between families and their schools. We hypothesised that parent involvement in school activities might positively impact AST indirectly (e.g., through an increased sense of social cohesion or connectivity), or directly through accompanying their child on the school journey to the same destination. We also measured perceptions of school community cohesion, hypothesising an increase in this variable may facilitate AST drawing on the above literature.

Individual factors

Research with children in middle school years and beyond show that active travel is gendered (Murray, 2009, Marzi et al., 2018), with boys having greater licence for independent mobility than girls, particularly in later childhood. Evidence suggests that this gender disparity becomes apparent in later childhood, rather than the early years of school (Goel et al., 2022). Ethnic and socio-economic differences have also been observed, but findings are inconsistent (Ikeda et al., 2018, Wilson et al., 2023).

Age-related variation exists in factors associated with children's AST (Oliver et al., 2014, Oliver et al., 2015, Smith et al., 2017, Egli et al., 2018, Ikeda et al., 2018, Ikeda et al., 2018c). There appears to be a u-shaped relationship for age, whereby younger children and adolescents are less likely to get to school actively, compared with older children (aged ~ 9-13y) in NZ (Smith et al., 2019, Wilson et al., 2023) and internationally (Rothman et al., 2018). There are clear age-related inclines in independent mobility (Shaw et al., 2015) and AST (Rothman et al., 2018) from early to middle childhood, and evidence suggests greater parental safety concerns for younger rather than older children (Smith et al., 2019a). It is possible there are interactions between age and social constructions of childhood and children, and how this filters down to parental safety concerns, perceptions of their child's ability, and subsequent licence for independent mobility. In the absence of licence for independent mobility and parent capacity to accompany their child on an active journey, chauffeuring children to school becomes the norm. The social construction of children as 'being' and/or 'becoming' brings into play adult assumptions about children's capability and capacity (Liebel, 2014). The evolution of children's capacities can be seen as a complex and undulating web of developing, participatory, and protective concepts. For the most part, adult concerns for children's safety (protection of children) overrides participatory opportunities, negatively impacting their rights to get around their neighbourhoods actively. Pervasive concepts of developing capabilities and children as 'becoming' mean that these restrictions on mobility through various pathways (e.g., concerns regarding safety or

assumptions about children's ability) are heightened for younger children. In this research we focused on understanding factors associated with AST in the earliest school years, and hypothesised that parent perceptions about their child at school, conceptualised as indicators of perceived child capacity, would be associated with AST.

Summary and study aim

There is a paucity of information related to factors of importance for children in their earliest years of school, arguably the optimal life stage for intervention to achieve long-term health gain. In the context of limited budget and capacity, age-specific and evidence-based information on factors of importance for supporting AST in early life may yield important insights. A small but growing evidence base suggests neighbourhood social factors may play an important role in supporting AST, and knowledge regarding the social connections between schools and families is needed. Socio-ecological approaches are useful to understand factors of importance for AST across varying levels. In this research, we aimed to determine the relationships between individual, family/household, school, and community factors and children's AST at 6y and at 8y of age.

Materials and methods

Data source: Growing up in New Zealand (GUiNZ)

Data for this study were drawn from the GUiNZ maternal antenatal survey and maternal surveys at the 6y and 8y waves (Morton et al., 2012). GUiNZ is a longitudinal cohort study focusing on factors that may influence children's development over time (Morton et al., 2012). The first phase of GUiNZ involved an antenatal survey with pregnant mothers of 6846 children and their partners. Pregnant mothers needed to be residing in the Tāmaki Makaurau/Auckland and Waikato Regions at recruitment, and their children were born between March 2009 and May 2010. Comparison with national birth data from 2007 to 2010 showed birth parameters for the GUiNZ children were generally closely aligned to all contemporary births nationwide (Morton et al., 2015).

While GUiNZ is not focused on AST or related variables, school travel mode was assessed at ages 6y and 8y, as well as perceptions of social relationships and the school environment, providing a unique opportunity to examine factors related to AST during these early school years. Specifically, the survey asked parents about their involvement with school activities, perceptions of school community cohesion, and perceptions about their child at school. While conceptually similar, these measures differed slightly across survey waves. In addition, at 8y only, children reported on their peer and school relationships, providing a new opportunity to explore this factor in relation to AST (where a higher level of connections with others and happiness at the school was hypothesised to link to greater AST through more opportunities to travel with others). Full survey details and data dictionaries are available on the GUiNZ website (Growing Up in New Zealand, 2023). Ethical approval to conduct the study was provided by the Ministry of Health Ethics Committee (NTY 08/06/055).

GUiNZ child participants will have been in school years 1 or 2 during the 6y measurement wave, and school years 3 or 4 for the 8y wave. These stages within school are significantly different - shifting from a focus on transition to school in years 1–2, to increased independence in years 3–4, alongside increased physical skill capability. Thus, it could be contended that associates with AST may also differ over this life stage, for example due to increased autonomy and/or capacity. While not fit-for-purpose, the GUiNZ study offers a unique opportunity to address current knowledge gaps by providing new evidence that examines socio-environmental factors of importance for AST in early life.

Cross-sectional analyses: Participant inclusion criteria and GUiNZ measures used

Participants for the 6y cross-sectional analyses were eligible if they met the following criteria: (1) with child ID, (2) mothers usually residing in NZ, (3) children usually residing in NZ, (4) children who attend school in NZ, (5) response to the question about "active travel mode". For the 8y analyses, in addition to the 6y inclusion criteria, participants who had moved house or attended any other school since they were 6y were excluded, in order for us to retain environmental perception measures from the 6y phase. Measures specific to the current study are outlined below and in Table 1.

Dependent variable

Usual mode of travel to/from school (measured at 6y and 8y). Children's usual mode of travel to/from school was assessed using the following question: *"What forms of transport do you mostly use to get your Growing Up in New Zealand study child/children to and from school?"*. The responses were dichotomised into active travel (i.e., bicycle, scooter and walking), and passive travel (i.e., car, school bus, public transport, and taxi). We recognise that public transport is associated with increased physical activity (Rissel et al., 2012), however for this examination with young children, we were specifically interested in active travel modes for the full school journey. Similarly, while independent mobility is an important contributor to child development and wellbeing (Badland and Oliver, 2011, Marzi and Reimers, 2018), the focus of this research was on getting to school actively, irrespective of accompaniment.

Independent variables

Importance of living close to school (6y only). Importance of living close to school was measured by the summed score of two items with 5-point Likert scales focusing on living within the school zone and accessing school easily. Responses ranged from not at all important (1) to very important (5). This variable was measured at 6y and used for both the 6y and 8y analyses (as participants in the 8y dataset had not moved since 6y).

Parent/caregiver perceptions of child at school (6y). At 6 years, this was a latent variable measured by three observed variables, being the parent/caregiver perceptions of their child's independence, happiness, and relationships. Each variable comprises five items, each scored on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5).

Parent/caregiver perceptions of child at school (8y). At 8y, this was an observed variable measured by the summed score of three binary items: Parent/caregiver perceptions of child having good friends at school, child seems happy, and the child's needs are met.

Parent/caregiver involvement with school (6y). At 6y, parent/caregiver involvement with school was assessed by the summed score of three items with binary response, which measured three aspects: child is happy in school, child can mix with other children, and child is independent enough to cope with school.

Parent/caregiver involvement with school (8y). This was measured by the summed score of three binary items: The school keeps me informed about my child's learning, there is good parental input into the school, and the school seeks parental input.

Child and household characteristics (6y and 8y). Child's biological sex (female, male), self-prioritised ethnicity (i.e., identifying with one ethnic group only, categorised as: NZ European, Māori, Pacific, Asian, Other), neighbourhood level deprivation using the NZDep2013 (a 10-point ordinal scale; (Atkinson et al., 2014)), and number of people living in house (6y)/number of young adults under 20 and children living in house (8y) were included in analysis.

Child-reported peer and school relationships (8y). This was a new variable included in the 8y survey and was measured by the summed score

Table 1
Observed variables and their descriptive statistics for included participants at the 6 year and 8 year study waves of the Growing Up in New Zealand Study.

Variables	Description of variable at 6 years	Categories	% or mean ± SD	Description of variable at 8 years	Categories	% or mean ± SD
Dependent variable						
Active school travel	Usual mode of travel to/from school	Passive travel (car, public transport, school bus)	1097 (65.7 %)	Usual mode of travel to/ from school	Passive travel (car, public transport, school bus)	590 (66.7 %)
		Active travel (walk, bike, scooter)	573 (34.3 %)		Active travel (walk, bike, scooter)	295 (33.3 %)
Independent variables						
Number of people living in house	How many people live in your house? Number of people	2	64 (3.8 %)	How many other children and young adults aged 20 and under live with you	0	79 (8.9 %)
		3	226 (13.5 %)		1	442 (49.9 %)
		4	622 (37.2 %)		2	257 (29.0 %)
		5	474 (28.4 %)		3	69 (7.8 %)
		6	167 (10.0 %)		4	26 (2.9 %)
		7+	117 (7 %)		5+	12 (1.3 %)
Sex	Biological sex of child	Female	792 (47.4 %)	Biological sex of child	Female	396 (44.7 %)
		Male	878 (52.6 %)		Male	489 (55.3 %)
Ethnicity	Self-prioritised ethnicity	New Zealand European	1076 (64.4 %)	Self-prioritised ethnicity	New Zealand European	611 (69.0 %)
		Māori	277 (16.6 %)		Māori	133 (15.0 %)
		Pacific	173 (10.4 %)		Pacific	59 (6.7 %)
		Asian	88 (5.3 %)		Asian	52 (5.9 %)
		Other + MELAA + New Zealander	56 (3.3 %)		Other + MELAA + New Zealander	30 (3.4 %)
Neighbourhood Deprivation	NZDep2013 Index of Deprivation	1 (least deprived)	214 (12.8 %)	NZDep2013 Index of Deprivation	1 (least deprived)	139 (15.7 %)
		2	223 (13.4 %)		2	132 (14.9 %)
		3	182 (10.9 %)		3	101 (11.4 %)
		4	195 (11.7 %)		4	116 (13.1 %)
		5	176 (10.5 %)		5	92 (10.4 %)
		6	148 (8.9 %)		6	72 (8.1 %)
		7	134 (8.0 %)		7	61 (6.9 %)
		8	131 (7.8 %)		8	64 (7.2 %)
		9	125 (7.5 %)		9	55 (6.2 %)
		10 (most deprived)	135 (8.1 %)		10 (most deprived)	53 (6.0 %)
		missing	7 (0.4 %)			
Importance of living close to school	Summed score of two items		8.17 ± 1.72	Summed score of two items		8.21 ± 1.84
	1. Importance of "The school is easy to access"	Not at all important	25 (1.5 %)	1. Importance of "The school is easy to access"	Not at all important	10 (1.1 %)
		Not important	57 (3.4 %)		Not important	26 (2.9 %)
		Neither important nor unimportant	140 (8.4 %)		Neither important nor unimportant	78 (8.8 %)
		Important	655 (39.2 %)		Important	338 (38.2 %)
		Very Important	793 (47.5 %)		Very Important	433 (48.9 %)
	2. Importance of "We live within the school zone"	Not at all important	75 (4.5 %)	2. Importance of "We live within the school zone"	Not at all important	42 (4.7 %)
		Not important	149 (8.9 %)		Not important	78 (8.8 %)

(*continued on next page*)

Table 1 (*continued*)

Variables	Description of variable at 6 years	Categories	% or mean ± SD	Description of variable at 8 years	Categories	% or mean ± SD
		Neither important nor unimportant	293 (17.5 %)		Neither important nor unimportant	157 (17.7 %)
		Important	495 (29.6 %)		Important	253 (28.6 %)
		Very Important	658 (39.4 %)		Very Important	355 (40.1 %)
Parent/caregiver perceptions of child's independence, happiness, relationships	*Latent variable*					
	1. I think that my child/children are happy in their school	Strongly disagree	15 (0.9 %)	1. My child has good friends atschool	No	790 (89.3 %)
		Disagree	21 (1.3 %)		Yes	95 (10.7 %)
		Neither agree nor disagree	61 (3.7 %)			
		Agree	739 (44.3 %)			
		Strongly agree	834 (49.9 %)			
	2. I think that my child/children can mix with other children well at school	Strongly disagree	20 (1.2 %)	2.The children seem happy	No	722 (81.6 %)
		Disagree	20 (1.2 %)		Yes	163 (18.4 %)
		Neither agree nor disagree	82 (4.9 %)			
		Agree	783 (46.9 %)			
		Strongly agree	765 (45.8 %)			
	3. I think that my child/children is independent enough to cope with school	Strongly disagree	14 (0.8 %)	3. All the child's needs are met	No	881 (99.5 %)
		Disagree	15 (0.9 %)		Yes	4 (0.5 %)
		Neither agree nor disagree	54 (3.2 %)			
		Agree	768 (46.0 %)			
		Strongly agree	819 (49.0 %)			
Parent/caregiver involvement with school	Summed score of three items		1.91 ± 0.71	Summed score of three items		
	1. Gone to a community or school event in past month	Not in past month	405 (24.3 %)	1. They keep me informed aboutmy child's learning	No	778 (87.9 %)
		In past month	1265 (75.7 %)		Yes	107 (12.1 %)
	2. Regular supervising e.g. walking school bus, road patrol, parent help	No	1275 (76.3 %)	2. There is good parental input into the school	No	874 (98.8 %)
		Yes	395 (23.7 %)		Yes	11 (1.2 %)
	3. School involvement (other non-AST forms of involvement)	No	134 (8.0 %)	3. The school seeks parental input	No	883 (99.8 %)
		Yes	1536 (92.0 %)		Yes	2 (0.2 %)
Mediators						
Proximity	How far away is your child's school from your home?	Less than 1 km	722 (43.2 %)	How far away is your child's school from your home?	Less than 1 km	367 (41.5 %)
		1—–5 km	728 (43.6 %)		1—–5 km	404 (45.6 %)
		Greater than 5 km	220 (13.2 %)		Greater than 5 km	114 (12.9 %)
School community cohesion	Summed score of four items		16.72 ± 1.99			
	1. Importance of "The school fosters a strong parent, family, or community involvement"	Not at all important	5 (0.3 %)	1. I feel welcome at school	No	870 (98.3 %)
		Not important	26 (1.6 %)		Yes	15 (1.7 %)
		Neither important nor unimportant	133 (8.0 %)			
		Important	815 (48.8 %)			
		Very Important	691 (41.4 %)			
	2. Importance of "It is the same school as attended by family/ friends/ other known children"	Not at all important	100 (6.0 %)	2. Am able to visit my child's classroom	No	881 (99.5 %)
		Not important	212 (12.7 %)		Yes	4 (0.5 %)

(*continued on next page*)

Table 1 (*continued*)

Variables	Description of variable at 6 years	Categories	% or mean ± SD	Description of variable at 8 years	Categories	% or mean ± SD
		Neither important nor unimportant	444 (26.6 %)			
		Important	519 (31.1 %)			
		Very Important	395 (23.7 %)			
	3. I feel welcome to visit my child/ children's school	Strongly disagree	20 (1.2 %)	3. There is a board of trustees that represents our community	No	883 (99.8 %)
		Disagree	25 (1.5 %)		Yes	2 (0.2 %)
		Neither agree nor disagree	63 (3.8 %)			
		Agree	635 (38.0 %)			
		Strongly agree	927 (55.5 %)			
	4. I think that my child/children feel/'s like they belong in their school	Strongly disagree	15 (0.9 %)			
		Disagree	18 (1.1 %)			
		Neither agree nor disagree	51 (3.1 %)			
		Agree	720 (43.1 %)			
		Strongly agree	866 (51.9 %)			
Child-reported peer relationships	(new for 8y)	n/a	n/a	Summed score of four items		12.87 ± 1.74
				1. My friends are usually nice to me	I do not agree	8 (0.9 %)
					Agree a little bit	91 (10.3 %)
					Agree somewhat	92 (10.4 %)
					Agree a lot	290 (32.8 %)
					Totally agree	404 (45.6 %)
				2. I have enough friends	I do not agree	24 (2.7 %)
					Agree a little bit	50 (5.6 %)
					Agree somewhat	57 (6.4 %)
					Agree a lot	187 (21.1 %)
					Totally agree	567 (64.1 %)
				3. I look forward to school	Never	32 (3.6 %)
					Sometime	247 (27.9 %)
					Often	237 (26.8 %)
					Almost always	369 (41.7 %)
				4. I like school	Never	19 (2.1 %)
					Sometime	151 (17.1 %)
					Often	254 (28.7 %)
					Almost always	461 (52.1 %)
Control variables						
Maternal education	The highest qualification of mother	No secondary school qualification	45 (2.7 %)	The highest qualification of mother	No secondary school qualification	16 (1.8 %)
		Secondary school/ NCEA 1–4	347 (20.8 %)		Secondary school/ NCEA 1–4	161 (18.2 %)
		Diploma/Trade certification/NCEA 5–6	453 (27.1 %)		Diploma/Trade certification/NCEA 5–6	219 (24.7 %)
		Bachelor's degree	444 (26.6 %)		Bachelor's degree	262 (29.6 %)

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Table 1 (*continued*)

Variables	Description of variable at 6 years	Categories	% or mean ± SD	Description of variable at 8 years	Categories	% or mean ± SD
		Higher degree	362 (21.7 %)		Higher degree	227 (25.6 %)
		Missing	19 (1.10 %)		Missing	0 (0.0 %)
Times moved	How many times have you moved house since your Growing Up in New Zealand study child/children were 4 and a half years old?	0 = None	1168 (69.9 %)	n/a	n/a	n/a
		1 = One	355 (21.3 %)			
		2 = Two	88 (5.3 %)			
		3 = Three	30 (1.8 %)			
		4 = Four	14 (0.8 %)			
		5 = Five	6 (0.4 %)			
		6 = Six	5 (0.3 %)			
		7 = Greater than or equal to seven	4 (0.2 %)			

of two 5-point Likert questions (1 = I don't agree, 5 = totally agree): "My friends are usually nice to me", "I have enough friends" and two 4-point Likert questions (0 = never, 3 = almost always) "I look forward to school" and "I like school".

School community cohesion (6y). School community cohesion was measured by the summed scored of four items: "Importance of the school fosters a strong parent, family, or community involvement", "Importance of it is the same school as attended by family/ friends/ other known children" with a 5-point Likert scale, ranging from not at all important (1) to very important (5); "I think that my child/children feel/ 's like they belong in their school" and "I think that my child/children are happy in their school" with a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5).

School community cohesion (8y). This variable was measured by three binary items: "I feel welcome at school", " I am able to visit my child's classroom" and "There is a board of trustees that represents our community."

Perceived home-school distance (6y). Perceived home-school distance was measured by asking "Approximately how far away is your child/ children's school from your home?". Responses were categorised into "as less than 1 km", "1–5 km" or "greater than 5 km". This variable was measured at 6y and used for both the 6y and 8y analyses (as participants in the 8y dataset had not moved since 6y).

Control variables

Two control variables were included in this study: Maternal education (No secondary school qualification, Secondary school/NCEA 1–4, Diploma/Trade certification/NCEA 5–6, Bachelor's degree, Higher degree) and number of times moved since child was 4 years old (none, one, two, three, four, five, six and greater than or equal to seven). For number of times moved, the corresponding 8y item was used to screen participants out of analyses so that only participants who had not moved since the 6y wave were included in analyses.

Statistical analysis

Descriptive statistics for participant characteristics and study variables at each survey wave were calculated. Since the variables were a mix of ordinal and binary, Kendall's tau was employed to evaluate correlations across variables at 6y and 8y. Structural equation modelling (SEM) was conducted using the R package "lavaan" (Latent Variable Analysis) version 0.6–9 (Rosseel, 2012) in Rstudio (RStudio Team, 2020). The diagonally weighted least squares (DWLS) method was employed to test the conceptual model due to the presence of categorical variables. SEM is a robust second generation multivariate statistical approach that combines factor analysis (measurement model) and multiple regression analysis (structural model) simultaneously. Strengths of SEM are the ability to estimate multiple and interrelated dependent relationships, the generation of a theory-driven and robustly tested model for the complete set of relationships between variables, the ability to represent unobserved theoretical constructs, and the ability to improve on the statistical estimation of relationships through accounting for measurement error (Kline RB, 2016). Standardised coefficients are presented for all models to allow comparability between estimates from different variables and pathways.

A measurement model (i.e., parents/caregivers' perceptions of child at school) was specified by a group of observed variables and examined how well they explain the latent variable. Model specification was informed by Sallis and colleagues' socio-ecological model (Sallis, et al., 2006) and Mitra's Behavioural Model of School Transport (Mitra, 2013) as employed in Ikeda et al. (Ikeda, et al., 2019). Of note, this was secondary analysis of an existing dataset and the GUiNZ study was not focused on AST or its predictors. Therefore we did not have a comprehensive suite of variables that captured all factors of importance identified in these two models. Convergent validity was assessed using factor loadings ($\lambda \geq 0.5$), average variance extracted (AVE $\geq$ 0.5), and construct reliability (CR $\geq$ 0.7) (Fornell and Larcker, 1981, Chin, 1998). Since there was only one latent variable in the conceptual model, the discriminant validity was not assessed in this analysis. Overall model fit was determined by four fit indices: the root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), Tucker-Lewis index (TLI) and comparative fit index (CFI). The cut-off value for a 'good' fit were determined as SRMR $\leq$ 0.08, RMSEA $\leq$ 0.06, CFI $\geq$ 0.95 and TLI $\geq$ 0.95 (Hu and Bentler, 1999). SRMR $\leq$ 0.08, RMSEA $\leq$ 0.08, TLI $\geq$ 0.90 and CFI $\geq$ 0.90 were considered as an 'acceptable/adequate' fit (Kline, 2016). The direct and indirect effects were tested in the structural model by using a percentile bootstrap approach considering a 95 % confidence interval (bootstrap replication = 2000). Since the result of the preliminary exploratory factor analysis for potential latent variables showed weak factor loadings (<0.4), a path model was employed to test the relationship between AST and other study variables. Path modelling is a special form of SEM without latent variables in a model, which can be used to test direct and indirect associations between observed endogenous and exogenous variables (Barbeau, et al., 2019).

Results

Fig. 1 provides the flow diagram of the participants included and excluded from the study. Apart from the criteria listed above, recognising ethnicity might be an essential background factor, we excluded participants who had no ethnicity information. Responses with 97 (others), 98 (prefer not to say) and 99 (don't know) were also removed. Overall, the sample used in the current analysis included 1670 respondents for the year 6 analyses and 885 respondents for the year 8 analyses.

Descriptive statistics of participant demographics at age 6y and 8y are presented in the Table 1. Overall, 34.3 % and 33.3 % students reported active travel to schools (i.e., walking or biking) at 6y and 8y, respectively. The results of the correlation analyses are presented in Supplementary file 1. At 6y, one observed variable of school community cohesion, 'I think that my child/children feel(s) like they belong in their school,' showed moderate - strong correlations (Akoglu, 2018) with three observed variables of 'Parent/caregiver perceptions of child's independence, happiness, and relationships,' respectively. Otherwise, most statistically significant correlations between variables in different domains were only weak - moderate. There were fewer significant correlations between variables at 8y, and they were generally weaker than those observed at 6y.

Measurement model (6y)

Parents/caregivers' perceptions of child at school was specified by a combination of exploratory factor analysis and theory, comprising three observed variables: independence, happiness, relationships (Table 1). The measurement model showed good validity and reliability, with standardised factor loadings ranging from 0.60 to 0.88 ($p < 0.01$); AVE of 0.61; and CR of 0.82.

Structural model (6y)

Table 2 presents the hypothesised relationships between AST and other observed variables at 6y. Standardised path coefficients are presented in Fig. 2. The model revealed an acceptable model fit to the data: RMSEA = 0.05, SRMR = 0.07, CFI = 0.93 and TLI = 0.98, and explained 32.6 % of the variance in AST. After controlling for maternal education and number of times moved since age four, the model indicated that living close to schools had a significant and positive relationship with AST (estimate = 0.31, $p < 0.001$, 95 %CI: 0.17, 0.26). Meanwhile, a significant negative relationship with AST was found for perceived distance to schools (estimate = -0.46, $p < 0.001$, 95 %CI: −0.62, −0.40). There were no significant indirect paths in the model. However, two direct paths regarding school community cohesion were identified. Parent/caregiver involvement in schools (estimate = 0.19, $p < 0.001$, 95 %CI: 0.40, 0.66) and perceive child's independence (estimate = 0.56, $p < 0.001$, 95 %CI: 1.64, 1.98) were significantly and positively associated with school community cohesion.

Path analysis (8y)

Due to the poor overall model fit for the initial path model at 8y (RMSEA = 0.11, SRMR = 0.00, CFI = 0.40 and TLI = 0.94), the indirect paths were not included for this study wave. Instead, a path analysis was performed to explore the direct relationships between AST and other observed variables. It is worth noting here that with only direct paths, this is essentially a multiple regression model. However, in order to retain comparability with the 6y model (i.e., to calculate standardised estimates and use the same approach to calculating confidence intervals), a path model framework in lavaan was used. The model fit indices of the path model/multiple regression model were not reported because fully saturated models always fit the data perfectly (Kline, 2015). Table 2 and Fig. 3 show a similar positive association between AST and the importance of living close to schools (estimate = 0.19, $p < 0.001$, 95 %CI: 0.072, 0.204) and a negative relationship between AST and perceived distance to school (estimate = -0.47, $p < 0.001$, 95 %CI: −1.054, −0.709) at age eight. Negative associations were detected with parent/caregiver involvement with school (estimate = -0.071, $p = 0.099$, 95 %CI: −0.574, 0.028) and being of Pacific ethnicity (estimate = -0.100, $p = 0.03$, 95 %CI: −0.977, −0.113).

Discussion

In this research we aimed to determine relationships between AST and individual, family/household, school, and community factors for young children at ages 6y and 8y. Our analyses revealed that parents' perceived distance to school and parent reported importance of living close to school had significant relationships with whether children got to school actively at both time points. Distance to school is consistently observed as playing an overriding role on children's AST (Rothman et al., 2018, Smith et al., 2022). This research contributes to this evidence base by providing robust evidence for younger children in their earliest years of school. We also provide new insights that suggest that

Fig. 1. Sample selection.

Table 2
Standardized direct, indirect, and total effect of observed variables on AST at 6 years (n = 1670) and 8 years (n = 885).

Pathways	Adjusted model (6y)			Adjusted model (8y)
	Direct effect	Indirect effect	Total effect	Direct effect
Perceived home-school distance → Active school travel	−0.463***			−0.472***
Number of people living in house → Active school travel	0.046			0.039
Sex (Male) → Active school travel	−0.032			0.046
Area level deprivation → Perceived home-school distance → Active school travel		−0.002	0.019	
Area level deprivation → Perceived home-school distance	0.004			
Area level deprivation → Active school travel	0.021			−0.011
Māori *→Active school travel	0.002			−0.026
Pacific* →Active school travel	−0.032			−0.100**
Asian* →Active school travel	0.008			−0.011
Other* →Active school travel	0.040			0.003
Importance of living close to to school → Active school travel	0.305***			0.188***
School community cohesion → Active school travel	−0.069			−0.014
Parent/caregiver involvement with school → School community cohesion → Active school travel		−0.013	0.049*	
Parent/caregiver involvement with school → School community cohesion	0.192***			
Parent/caregiver involvement with school → Active school travel	0.060			−0.071*
Parent/caregiver perceptions of child at school → School community cohesion → Active school travel		−0.039	0.024	
Parent/caregiver perceptions of child at school → School community cohesion	0.561***			
Parent/caregiver perceptions of child at school → Active school travel	0.063			−0.033
Child reported peer relationship				0.041
Maternal education → Active school travel	0.003			0.019
Times moved since 4y → Active school travel	−0.040			
R^2	32.5 %			34.8 %

Note: Significance levels: *p < 0.10, **p < 0.05, ***p < 0.01.
Adjusted model: adjusted for maternal education and times moved since 4y at 6y and maternal education at 8y.
Ethnicity[1]: reference group: New Zealand European.

the impact of time from school/distance to school may be even greater for young children starting school (where no other significant relationships were observed) and also that these relationships may differ in important ways. For example, younger children are more likely to be accompanied for the school trip than older children (Hillman et al., 1990), meaning parents/caregivers have to consider the time commitment required for an active school trip and the need to co-ordinate multiple trips. Distance may also have a greater impact in younger childhood compared to late childhood, where parent/caregiver perceptions of their child's physical capacity to travel greater distances, or their ability to navigate longer routes (i.e., that are more complicated or have more hazards simply through increased distance) might impact mode choice. It is also possible that at younger ages, additional factors of importance for AST observed in older children - such as the social environment (Lin et al., 2017, Ikeda et al., 2019) - are yet to come into play.

A novel finding was the significant negative association between parent/caregiver involvement with the school and AST at 8y, to our knowledge this is a relationship that has not been examined in previous research. It is possible that involvement with schools encompasses an element of trip-chaining – specifically that being involved in activities at the school could result in time scarcity for parents, requiring them to use motorised transport to move quickly between activities (Buliung et al., 2011, Carver et al., 2019). In addition, at 8y, children of Pacific ethnicity were significantly less likely than children of NZ European ethnicity to get to school actively. In the NZ context, variable findings have been reported with regard to ethnicity and AST. A 2018 *meta*-analysis of studies across the country found no significant association between AST and ethnicity (Ikeda et al., 2018c). However, our most recent (2022) physical activity report card also showed that children and young people of Pacific ethnicity had considerably lower rates of AST than their non-Pacific peers (Wilson et al., 2023). It is possible this scenario has socio-economic drivers. For example, 56 % of people of Pacific ethnicity live in areas of high deprivation, compared with 20 % of the total population, they are less likely to own their own home, and are more likely to experience overcrowding (Ryan et al., 2019). Area-level deprivation has been associated with lower perceptions of neighbourhood safety and subsequent engagement in local neighbourhood environments (Jones et al., 2009). While area-level deprivation has been inconsistently linked with walkability (Macdonald et al., 2016), lower individual socio-economic status has been associated with residing in areas with lower quality pedestrian infrastructure (Lara and da Silva, 2020), which may dissuade active travel modes. A higher level of residential mobility has been reported for Pacific people compared with those of European ethnicity (Statistics New Zealand, 2016), which may impact school travel modes. However, this would not have been the case in the current study, as we limited the 8y sample to those who had not moved since the 6y study wave. Previous research has linked a range of socio-economic factors with whether children got to school actively – for example a positive relationship has been observed between AST and area-level deprivation (Ikeda et al., 2018c), while no meaningful difference by socio-economic status was observed in our 2022 physical activity report card (Wilson et al., 2023). Similarly, in the current research we found no association between AST and area-level deprivation at either age. We also conducted post-hoc analyses and found no significant difference in parent/caregiver perceived distance to school or importance of living close to school for Pacific children compared with non-Pacific children.

While no significant path to AST was observed for the other social variables included here, a fresh insight from the 6y the path analysis was the significant positive association between both parent/caregiver involvement in schools and parent's perceptions of their child's independence with parent perceived school community cohesion. No significant link between school community cohesion and AST was observed in this study. However, previous research with older children has demonstrated links between children's social environments and AST (Lin et al., 2017, Egli et al., 2018, Ikeda et al., 2019, Egli et al., 2020). As

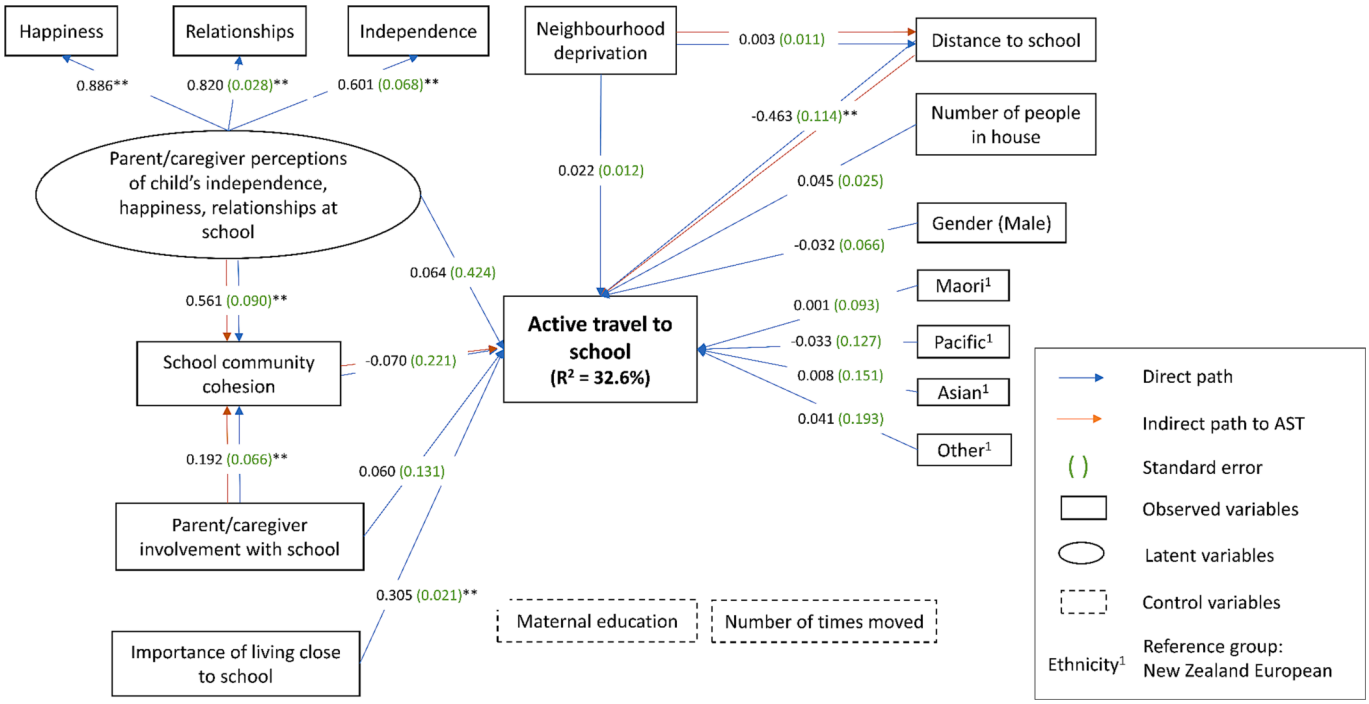

Fig. 2. Final SEM model describing the direct effects between variables at 6y (significance levels:**p < 0.01).

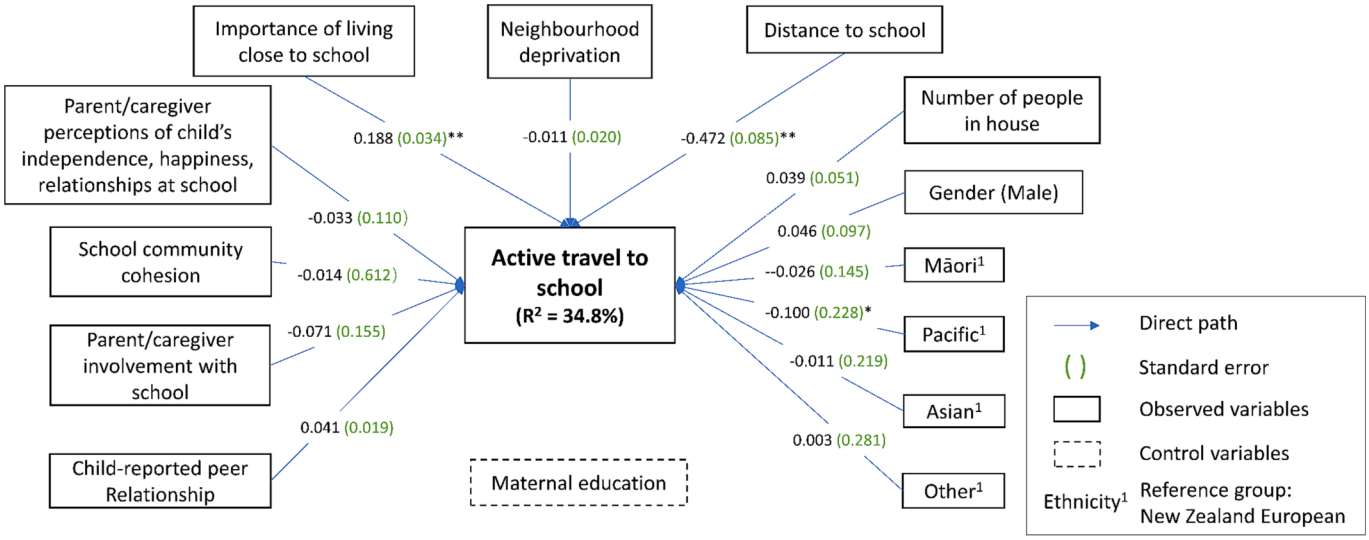

Fig. 3. Fully adjusted path model at 8y (significance levels:*p < 0.05, **p < 0.01).

such, our findings highlight the potential for improving parent involvement with schools (while simultaneously removing barriers to AST as noted above) and supporting children's independence for improved social cohesion and connectivity, in order to lay the foundation to support AST in later years.

Implications for policy and practice

This research, in agreement with previous studies, demonstrates the importance of children having access to schools nearby home to encourage AST. Policy and practice to ensure equity in liveable neighbourhoods including connecting schools with communities through safe and walkable school neighbourhoods are imperative (Ergler and Smith, 2023). Ongoing consideration and critique of school closures, amalgamation, and school site choice for new developments is essential in the context of supporting sustainable travel modes for children and their families (Centers for Disease Control and Prevention, 2006, Kearns et al., 2009). Considering threshold distances for biking are greater than for walking (D'Haese et al., 2011), it is also likely that providing infrastructure for biking could help overcome some of the distance-related barriers (although the evidence base to date has largely focused on older children and youth) (Chen et al., 2018, Pan et al., 2020, Hasanzadeh et al., 2022). The design of bike lanes and their integration with the wider transport system may be especially important to overcome parental concerns about safety for younger children (Smith et al., 2019a). For example, ensuring bike lanes are separated from other modes, are continuous (e.g., through targeted infrastructure planning and delivery *across* school catchment areas), and that are connected with other infrastructure (especially safe places to cross roads) are likely to be essential elements that make bike lanes usable (or not) for younger

children (Swain et al., 2023). Connecting bike lanes with existing bike paths and walkways can reduce distance to school through greater connectivity, however again safe design elements are likely to play an important role in their use (e.g., through provision of lighting, widening paths, and maintaining overgrowth). Under the condition of existence of safe, connected, and continuous biking infrastructure, ensuring equitable access to bikes (e.g., through bikes in schools programmes (Hawley et al., 2018)), bike skills training (Sersli et al., 2019), and cycle trains (O'Fallon, 2008) may also be important facilitators of biking in young children.

While threshold distances for walking are shorter than for biking, a number of strategies can still be employed to mitigate the negative impact of distance on walking to school. Developing a 'park and walk' programme can reduce congestion around the school gate through allocating parking areas within a short walk from school (Smith et al., in press, available on request). Ideally these parking spots can be located in areas with safe and connected pedestrian infrastructure to school, additionally facilitating children's independent walking to school. Walking school buses can also play an important role – especially where parent concerns for their child's (in)capacity to walk a given distance to school independently can be alleviated through adult supervision of groups of children walking to school together. Walking school buses provide multiple co-benefits, with demonstrated links between implementation of walking school bus programmes and AST (Smith et al., 2015), child self-efficacy for AST (Cramer et al., 2021), reducing congestion around schools (Collins and Kearns, 2010), and instilling social skills, joy, and confidence in children (Neuwelt and Kearns, 2006). A key challenge for walking school bus (and bike train) implementation and delivery is limited capacity of parents and schools to sustain these programmes – initiatives to encourage bus/train driver involvement and increase capacity are warranted (Smith et al., in press, available on request).

Strategies to simultaneously encourage parent involvement with schools (e.g., holding morning teas, hosting guest lectures on child wellbeing, learning etc., and running whole-of-family social activities) as well as supporting active travel for parents who are time scarce (e.g., supporting social connections between parents to share responsibility for walking children to school) could also be worth exploring.

Strengths, limitations, and recommendations for future research

This study focused on individual, household, and social environmental features as well as parent perceptions about distance to school. Regarding distance to school, we note that the aim of this research was not to determine an optimal distance threshold for AST (which would have necessitated a more precise measure), but rather to identify whether distance, alongside a range of socio-ecological factors, was associated with AST in young children. We also note that perceived and objective environmental measures differ in meaningful ways (McGinn et al., 2007, Arvidsson et al., 2012, Orstad et al., 2017), objective measures of distance to school are not necessarily more accurate (for example due to individuals taking routes to school other than the shortest origin–destination route) (Ikeda et al., 2018b), and that perceived measures are important associates of activity behaviours (Gebel et al., 2011, Arvidsson et al., 2012, Orstad et al., 2017, Ikeda et al., 2018, Smith et al., 2019a). Taken together, we propose that the approach to measure distance to school used in the current study was adequate to meet the research aims and also that future research might benefit from utilising both objective and perceived measures.

Safety is a key factor of importance for supporting AST (Ikeda et al., 2021) however no measures of safety related to the school journey were assessed in the GUiNZ study. Moreover, no objective assessments of the neighbourhood built environment (e.g., walkability, presence of bike lanes, etc.) were included in these analyses as these data were not available, and our focus was on the novel aspects of school social connections and child-reported relationships in AST. Our findings demonstrate the potential importance of these social factors for understanding the array of factors that can impact AST in young children, and we suggest consideration of these or similar factors in future studies of this type. Additionally, measuring neighbourhood safety, and including other objectively-assessed environmental measures known to be of importance for active school travel (Wong et al., 2011) would be worthwhile in future research. This approach would be especially useful to determine the relative contributions of different factors, or to determine the importance of social and cultural factors across varying physical environmental typologies (Hawley et al., 2019).

Measures have changed at each wave of the GUiNZ study, limiting direct comparability between time points. Existing longitudinal trend, cohort, and panel health surveys present considerable opportunity to understand the determinants of, and shifts in, AST over time. Given the importance of AST to health, and its (mostly) low and declining prevalence, efforts to integrate and use consistent measures of AST and related factors into such surveys, or the development of new longitudinal surveys specific to AST, are warranted.

Finally, little is known regarding public transport use in this young age group in NZ. School bus routes that are reliable; timely; tailored to where students live, learn, and play; and that connect to other services (e.g., commuter trains) may play an important role in reducing car use and increasing children's physical activity. Future research to explore these issues is warranted.

Conclusion

Distance remains the overriding factor associated with AST in young children – efforts to ensure children have easy access to, and are supported to attend, schools in close proximity from home are warranted. Targeted interventions that support and encourage AST for all children are necessary, given the low rates of AST overall observed in this study. Future work is needed to understand AST associates and barriers and enablers in young children.

Funding

This research was made possible with funding from the Ministry of Social Development's Children and Families Research Fund using - *Growing Up in New Zealand* data collected by the University of Auckland. The data has been accessed and used in accordance with the Growing Up in New Zealand Data Access Protocol.

CRediT authorship contribution statement

Melody Smith: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft. **Yijun Zhang:** Formal analysis, Funding acquisition, Writing – original draft. **Hayley McGlashan Fainu:** Funding acquisition, Methodology, Writing – review & editing. **Alana Cavadino:** Formal analysis, Funding acquisition, Writing – review & editing. **Jinfeng Zhao:** Data curation, Funding acquisition, Methodology, Writing – review & editing. **Susan Morton:** Data curation, Funding acquisition, Methodology, Writing – review & editing. **Debbie Hopkins:** Funding acquisition, Methodology, Writing – review & editing. **Harriette Carr:** Funding acquisition, Methodology, Writing – review & editing. **Terryann Clark:** Funding acquisition, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Acknowledgements

The authors would like to thank Joey Lee (Data Access Co-ordinator, Growing Up in New Zealand Study) for their support with data access, and Carol Green (carolgreen.net) for their illustration.

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